II Fórum de Morte Encefálica
DO CONSELHO FEDERAL DE MEDICINA
Brasília-DF, 25 de junho de 2019 | Local: Auditório do CFM

CFM

Teste de apnéia em Pediatria

Resolução CFM 2.173/2017

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Câmara Técnica de Morte Encefálica - CFM

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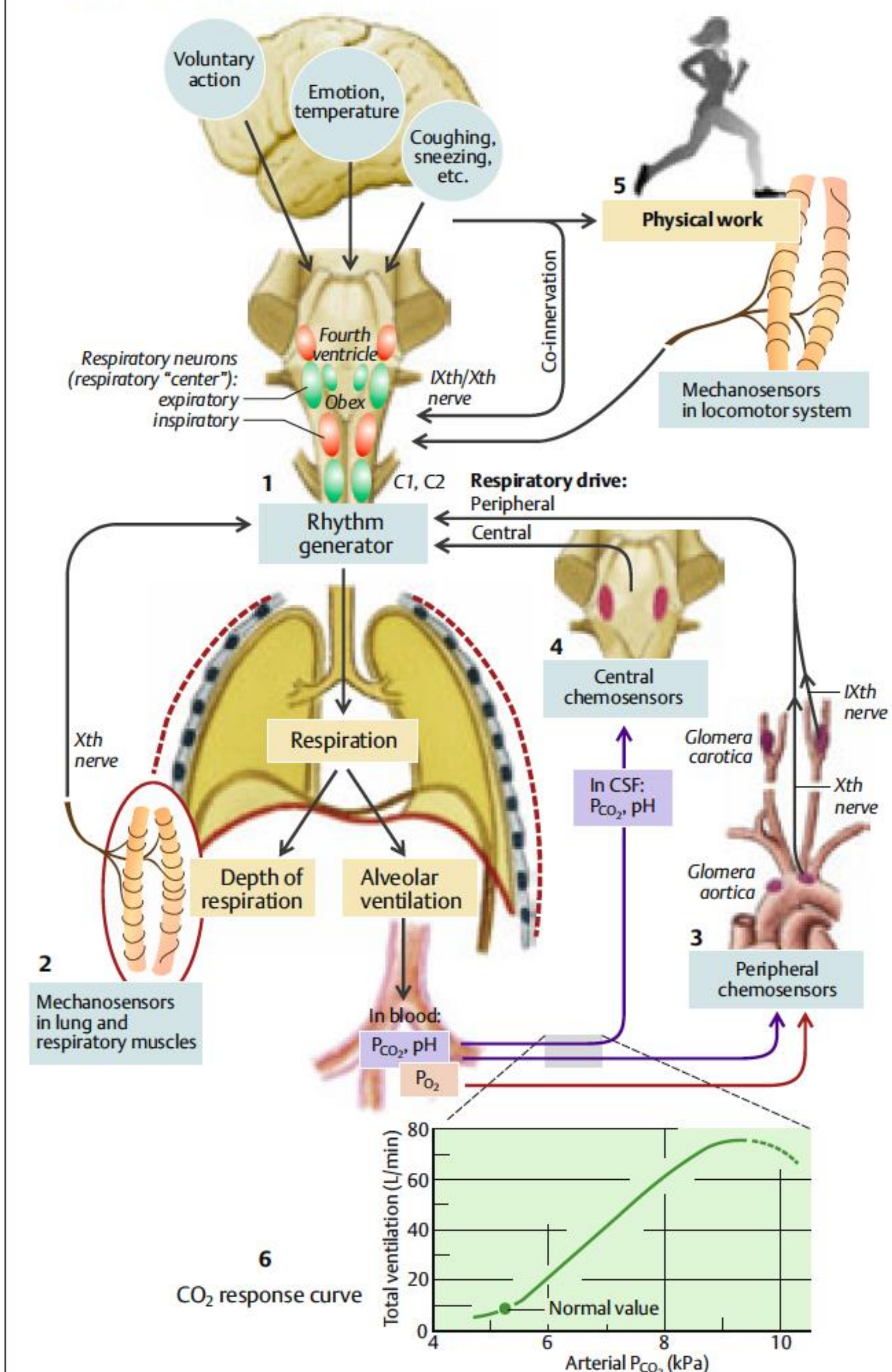
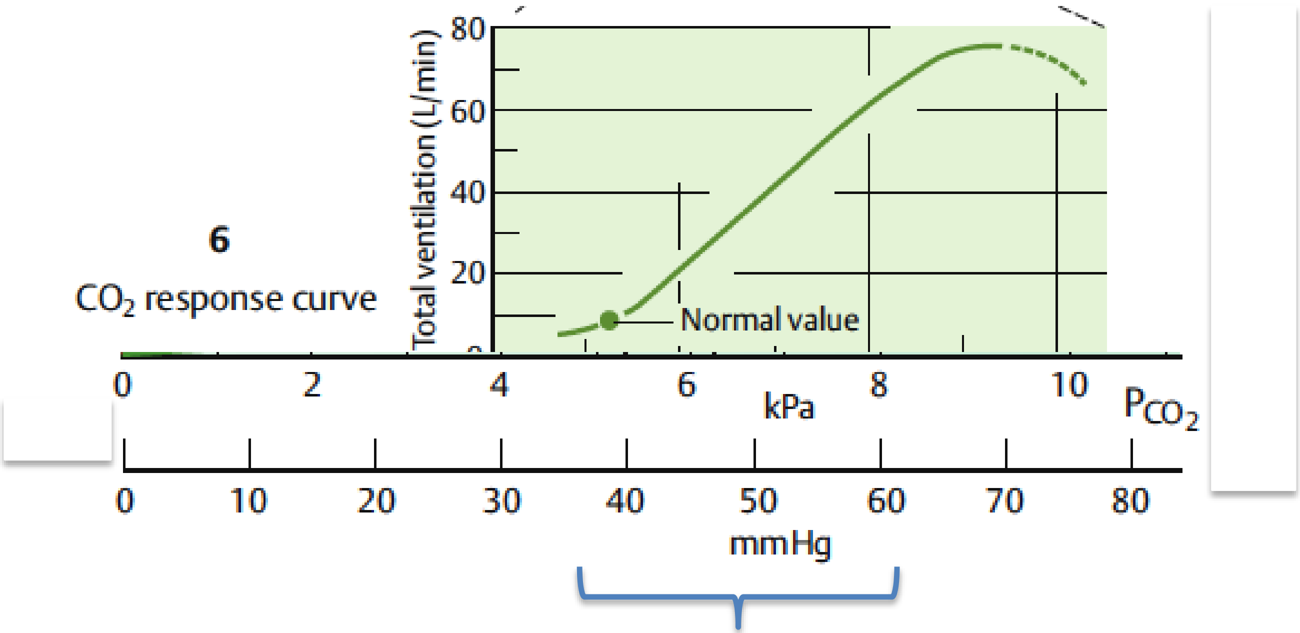
A. Respiratory control and stimulation



pCO_2 serum level & Total Ventilation Response



Aumento de 10x na Ventilação

Apnea Testing During Brain Death Assessment: A Review of Clinical Practice and Published Literature

J Brady Scott RRT-ACCS, Michael A Gentile RRT FAARC, Stacey N Bennett MSN ACNP, MaryAnn Couture RRT, and Neil R MacIntyre MD FAARC

Respir Care 2013;58(3):532–538

Apnea was first described in the medical literature in 1959.

- *It still lacks consensus standardization regarding the actual procedure, monitored parameters, and evidence based safety measures that may be used to prevent complications.*

- *Is an essential component in the clinical determination of brain death*

- ***It must be safe, accurate, and reproducible!***

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Resolução CFM 2173-2017 *(Morte Encefálica)*
TESTE DE APNÉIA

Ausência de movimentos respiratórios espontâneos, em resposta à estimulação máxima do centro respiratório ($PaCO_2$ >55 mmHg).

- **Método**: prevenir hipóxia e minimizar risco de intercorrências.

- **Pré-requisitos**: temperatura (esofagiana, vesical ou retal) >35°C, $SatO_2$ arterial >94% e PAS> 100 mmHg ou PAM $\geq$ 65 mmHg (adultos
  - ✓ Menores de 16 anos: tabela de tensão arterial anexa

	Pressão Arterial	
Idade	**Sistólica (mmHg)**	**PAM (mmHg)**
Até 5 meses incompletos	60	43
De 5 meses a 2 anos incompletos	80	60
De 2 anos a 7 anos incompletos	85	62
De 7 a 15 anos	90	65

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Respir Care 2013;58(3):532–538

Table 4. Apnea Testing Guidelines

Absence of breathing drive is tested with CO_2 challenge. Documenting a Pa_{CO_2} increase to above normal is typical practice. Test requires preparation.
Prerequisites
Normotensive
Normothermic
Euvolemic
Eucapnic (Pa_{CO_2} 35–45 mm Hg)
No hypoxia
No prior evidence of CO_2 retention (eg, COPD, severe obesity)
Procedure
Adjust vasopressors so systolic blood pressure is 100 mm Hg. Pre-oxygenate for at least 10 min with 100% oxygen so Pa_{O_2} is 200 mm Hg.
Reduce ventilator frequency to 10 breaths/min, to eucapnia.
Reduce PEEP to 5 cm H_2O (oxygen desaturation with decreasing PEEP may suggest difficulty with apnea testing).
If Sp_{O_2} remains < 95%, obtain a baseline arterial blood analysis (Pa_{O_2}, Pa_{CO_2}, pH, HCO_3^-, base excess).
Disconnect patient from ventilator.

Resolução CFM 2173-2017
Determinação da Morte Encefálica (ME)

1) Ventilação: FiO_2=1,0 (mínimo de 10 min) para atingir **idealmente** PaO_2 $\geq$200 mmHg e $PaCO_2$ entre 35 - 45 mmHg.
2) Monitorar oxigenação (oxímetro) e obter gasometria arterial inicial.
3) Desconectar ventilação mecânica.
4) Estabelecer fluxo contínuo de O2 por um cateter intratraqueal ao nível da carina (6 L/min), ou tubo T (12 L/min) ou CPAP (até 12 L/min + até 10 cm H2O).
5) Observar a presença de qualquer movimento respiratório por oito a dez minutos. Prever elevação da PaCO2 de 3 mmHg/min em adultos e de 5 mmHg/min em crianças para estimar o tempo de desconexão necessário.
6) Colher gasometria arterial final.
7) Reconectar ventilação mecânica

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Resolução CFM 2173-2017
Determinação da Morte Encefálica (ME)

***Teste positivo* (presença de apneia)** – **$PaCO_2$ >55 mmHg E ausência de movimentos respiratórios** *(mesmo que o teste tenha sido interrompido antes dos dez minutos previstos)*.

***Teste inconclusivo* – $PaCO_2$ final <55 mmHg, sem movimentos respiratórios**.

***Teste negativo* (ausência de apneia)** – **presença de movimentos respiratórios, mesmo débeis, com qualquer valor de $PaCO_2$**.

- ATENÇÃO: pacientes magros ou crianças os batimentos cardíacos podem mimetizar movimentos respiratórios débeis.

Apnea Testing During Brain Death Assessment: A Review of Clinical Practice and Published Literature

J Brady Scott RRT-ACCS, Michael A Gentile RRT FAARC, Stacey N Bennett MSN ACNP, MaryAnn Couture RRT, and Neil R MacIntyre MD FAARC

Respir Care 2013;58(3):532–538

Preserve oxygenation: insert insufflation catheter through the endotracheal tube and close to the level of the carina, and deliver 100% O_2 at 6 L/min.

Watch for respiratory movements for 8–10 min. Respiration is defined as abdominal or chest excursions, and may include a brief gasp.

Abort if systolic blood pressure decreases to < 90 mm Hg.

Abort if Sp_{O_2} is < 85% for > 30 s. Redo test with T-piece, CPAP of 10 cm H_2O, and 100% O_2 at 12 L/min.

If no respiratory drive is observed, repeat arterial blood analysis after 8 min.

If respiratory movements are absent and Pa_{CO_2} is 60 mm Hg (or 20 mm Hg increase in Pa_{CO_2} over a baseline normal Pa_{CO_2}) the apnea test is positive (ie, supports the diagnosis of brain death).

If the test is inconclusive but the patient is hemodynamically stable during the procedure, the test can be repeated for 10–15 min after another pre-oxygenation.

Critical Hemoglobin Desaturation Will Occur before Return to an Unparalyzed State following 1 mg/kg IV Succinylcholine. *Benumof JL. Anesthes. 1997;87:979-982.*

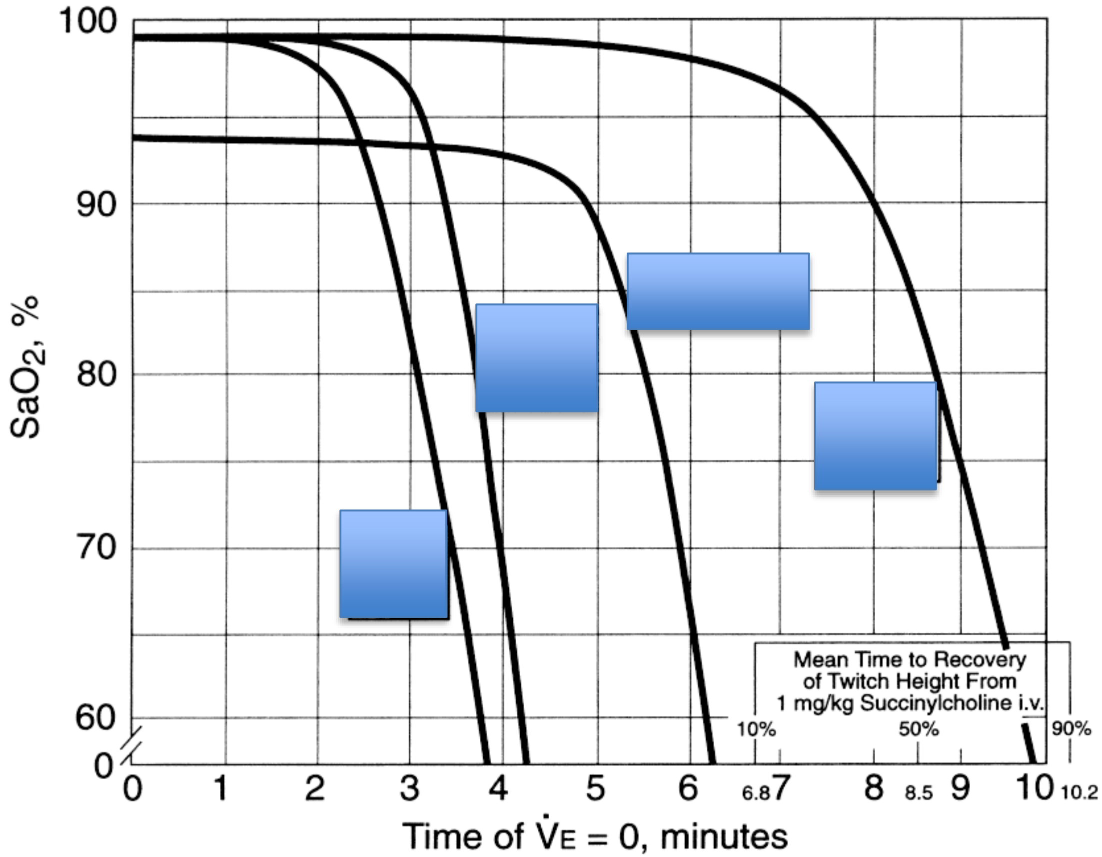

Figure 1. SaO^2versus time of apnea for various types of patients. The physiologic characteristics of these patients can be obtained from the author on request. The SaO^2versus time curves were produced by the computer apnea model of [2]. The mean times to recovery from 1 mg/kg intravenous succinylcholine (lower right hand corner) are taken from [11–16].

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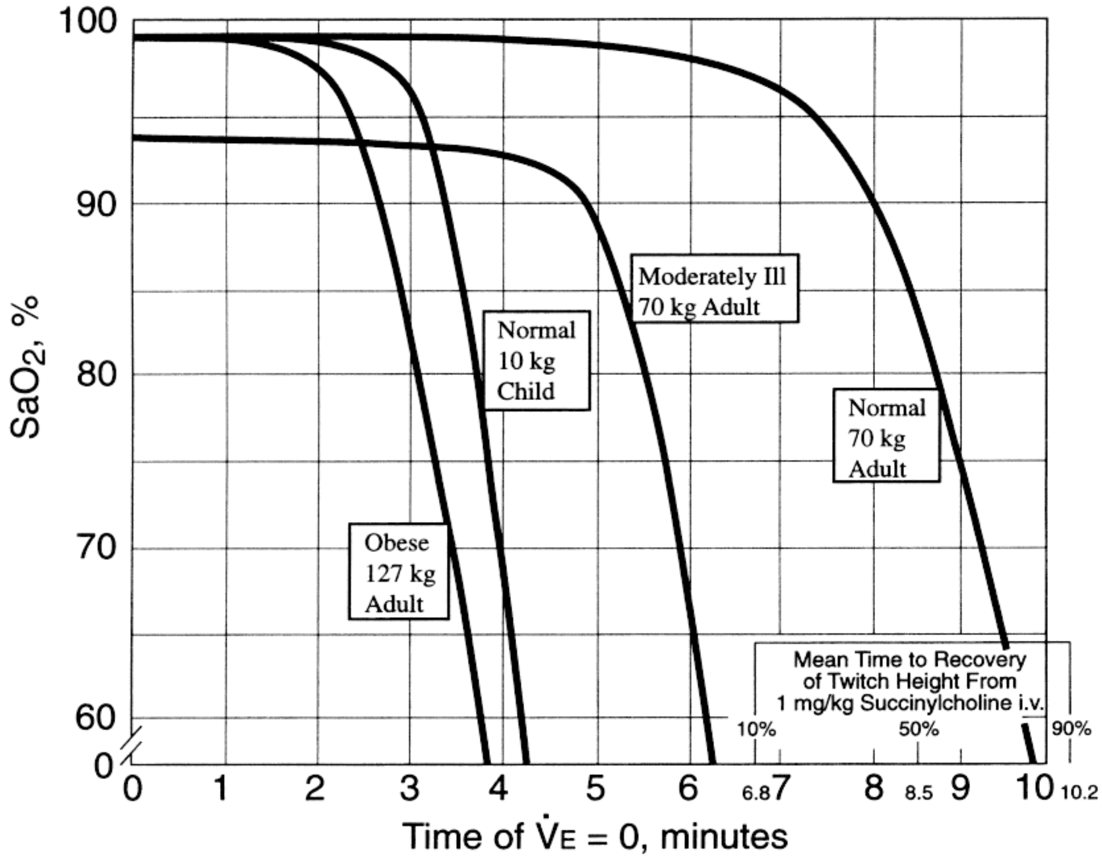

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Epidemiology of Brain Death in Pediatric Intensive Care Units in the United States

JAMA Pediatr. 2019;173(5):469-476.

Matthew P. Kirschen, MD, PhD; Conall Francoeur, MD; Marie Murphy, BSN, RN; Danielle Traynor, MSN, RN, CCRN;
Bingqing Zhang, MPH; Janell L. Mensinger, PhD; Rebecca Ichord, MD; Alexis Topjian, MD, MSCE;
Robert A. Berg, MD; Akira Nishisaki, MD, MSCE; Wynne Morrison, MD, MBE

Main causes of Brain Death in US-PICU:

- hypoxic-ischemic injury owing to cardiac arrest (52.7%),
- shock and/or respiratory arrest without cardiac arrest (12.6%)
- traumatic brain injury (20.0%).

Table 1. Causative Mechanisms of Brain Injury Leading to Brain Death

Causative Mechanisms	Prevalence, No. (%)
Total	3170 (100)
Cardiac arrest	1672 (52.7)
Trauma	383 (12.1)
Asphyxiation, asthma, or noninfectious respiratory failure	265 (8.4)
Drowning	193 (6.1)
Infection or sepsis	155 (4.9)
Poisoning, including by carbon monoxide	60 (1.9)
Neurovascular condition	60 (1.9)
Congenital heart disease, cardiomyopathy, or myocarditis	33 (1.0)
Brain tumor	16 (0.5)
Hepatic failure	15 (0.5)
Anaphylaxis	14 (0.4)
Ventricular shunt malfunction	11 (0.3)
Diabetic ketoacidosis	3 (0.1)
Traumatic brain injury	634 (20.0)
Motor vehicle accident	236 (7.4)
Suspected abusive trauma	155 (4.9)
Firearm-associated injury	59 (1.9)
Falls	23 (0.7)
Shock and/or respiratory failure without cardiac arrest	399 (12.6)
Asphyxiation, asthma, or noninfectious respiratory failure	99 (3.1)
Infection or sepsis	93 (2.9)

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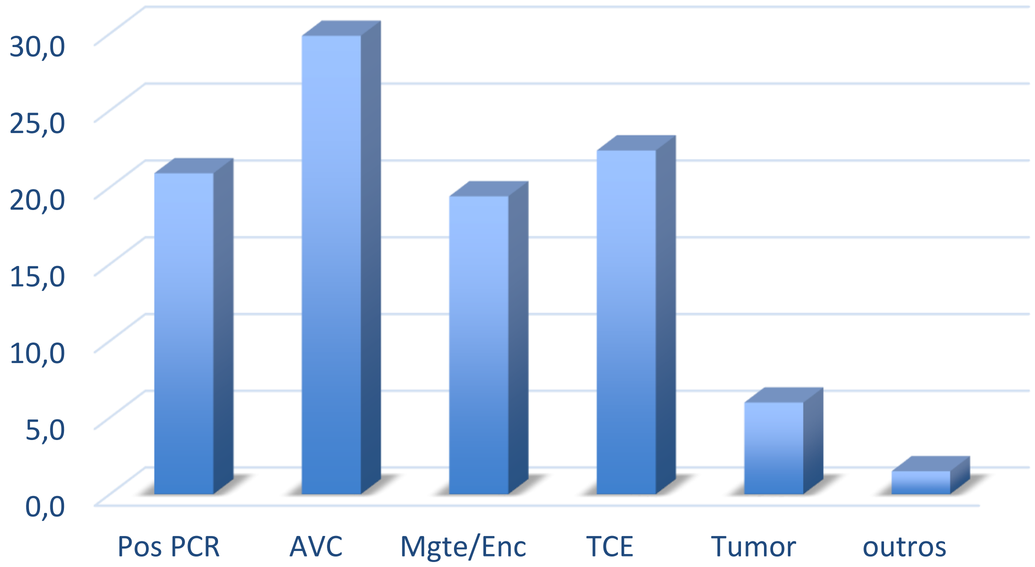
Brain death: medical management in seven Brazilian pediatric intensive care units

Lago P, Piva, J, Garcia PC et al

J Pediatr (Rio J). 2007;83(2):133-140

Causas de Morte Encefálica - 7 UTIP - Br



Fluid overload is not just a cosmetic aspect !

Fluid overload is associated with impaired oxygenation and morbidity in critically ill children

Pediatr Crit Care Med 2011 Vol. 12, No. 6

Ayse A. Arikan, MD; Michael Zappitelli, MD, MSc; Stuart L. Goldstein, MD; Amrita Naipaul, NP; Larry S. Jefferson, MD; Laura L. Loftis, MD

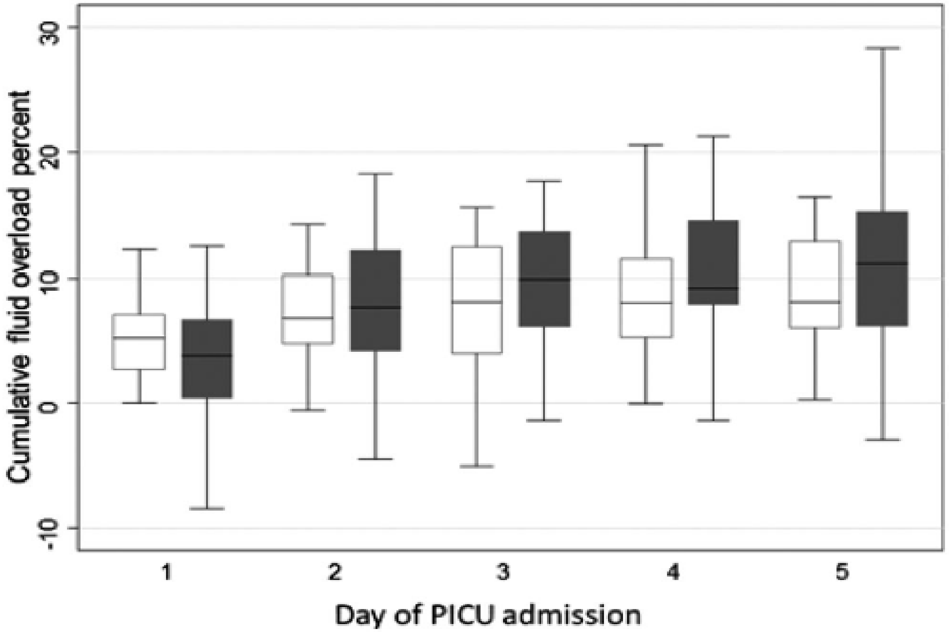


Table 3. Relationship between total fluid overload percent and oxygenation index

Total Fluid Overload %	Regression Coefficient	*p*
2.5%	0.05	.76
5%	0.05	.92
7.5%	0.05	.56
10%	0.08	.38
12.5%	0.10	.16
15%	0.12	.004
17.5%	0.20	<.001
20%	0.31	<.001

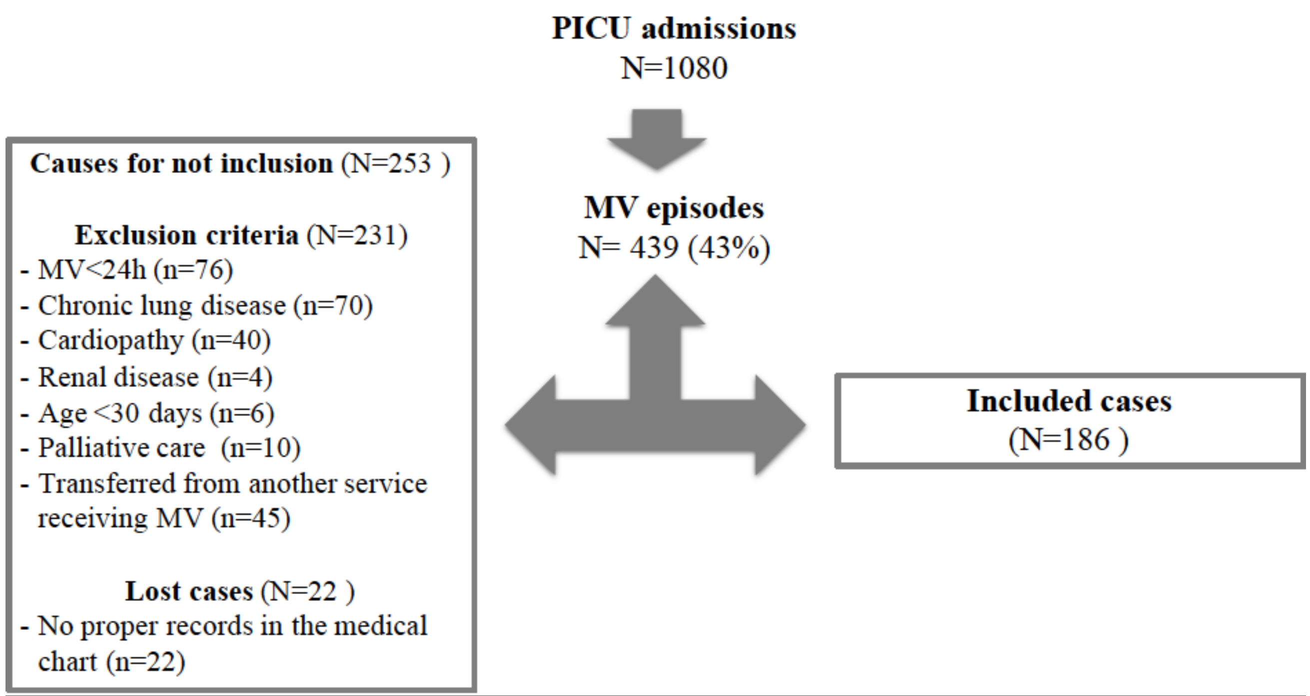
Open boxes = patients with OI < 11.5
Gray boxes = patients with OI > 11.5

Impact of the early positive cumulative fluid balance in acute ill children

Clarice Sinot, Jefferson Piva, Patrícia Fontela et al. Acta Pediatric (submitted 2019)

Inclusion criteria:

Children (1mo-18y) requiring MV >72hrs, **without** co-morbidities (cardiac disease, renal failure, chronic lung disease) or in palliative care .



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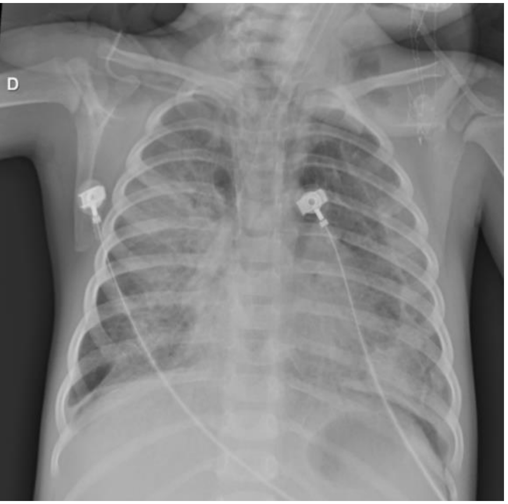


***Conclusion**: In a heterogeneous mechanically ventilated pediatric population, early cumulative fluid overload (≥ 10% weight) is frequently observed and associated with higher ventilatory parameters and renal replacement therapy, …. but not affecting the mortality when adjusted to the confounding factors.*

JAMA Pediatrics | Original Investigation January 2018

Association Between Fluid Balance and Outcomes in Critically Ill Children
A Systematic Review and Meta-analysis

Rashid Alobaidi, MD; Catherine Morgan, MD, MSc; Rajit K. Basu, MD; Erin Stenson, MD; Robin Featherstone, MLIS; Sumit R. Majumdar, MD, MPH; Sean M. Bagshaw, MD, MSc

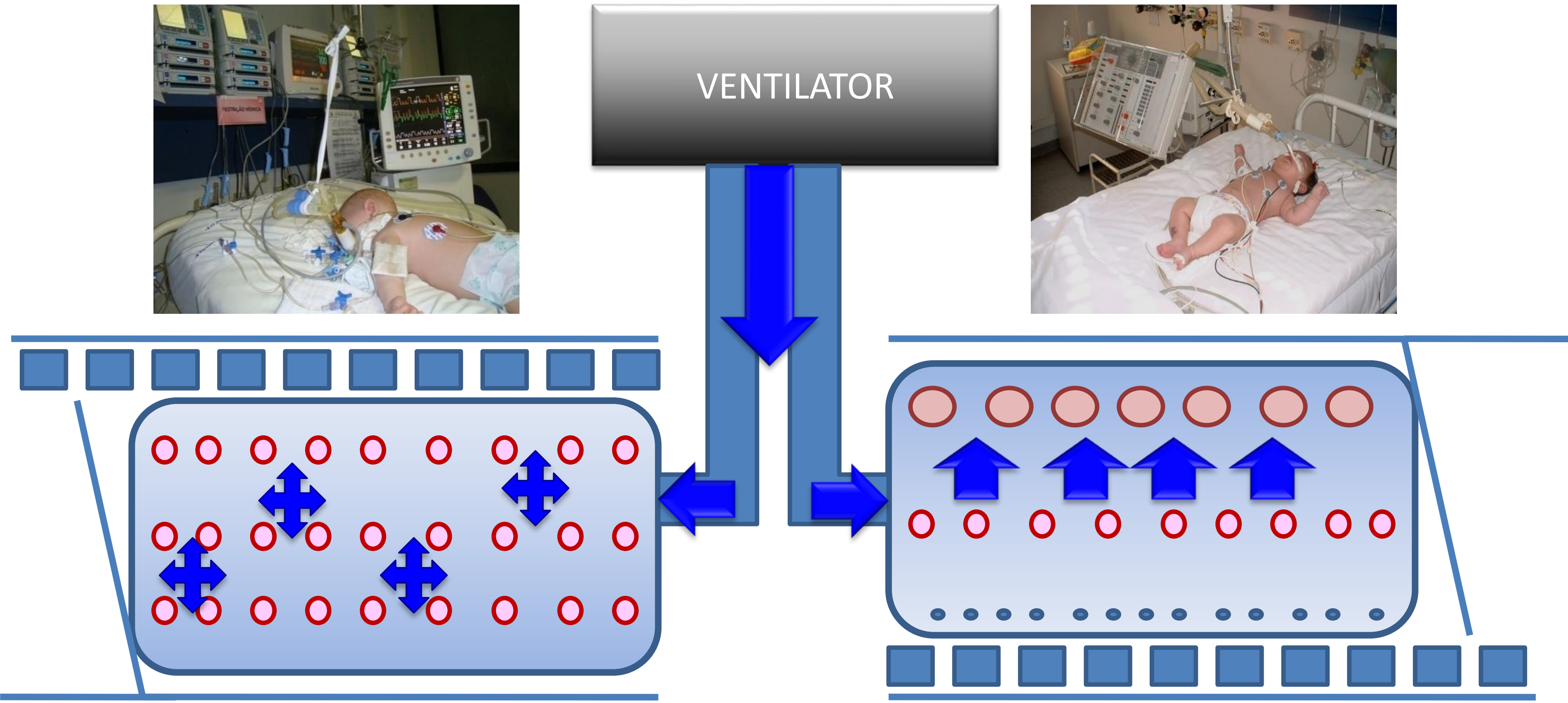
44 studies (7,507 children)

- Prevalence of fluid overload (FO): Median = 33% (10%-83%).

FO was associated with

- In-hospital mortality OR= 4.34 [3.0-6.3];
- Prolonged mechanical ventilation (>48 hours) OR=2.1 [1.3-3.7];
- Acute Kidney Injury: OR= 2.4 [1.3-4.4];

MV : PRONE X SUPINE



What's new in mechanical ventilation in patients without ARDS: lessons from the ARDS literature

Intensive Care Med (2016) 42:787–789

Ary Serpa Neto[1,2,3] and Samir Jaber[4*]

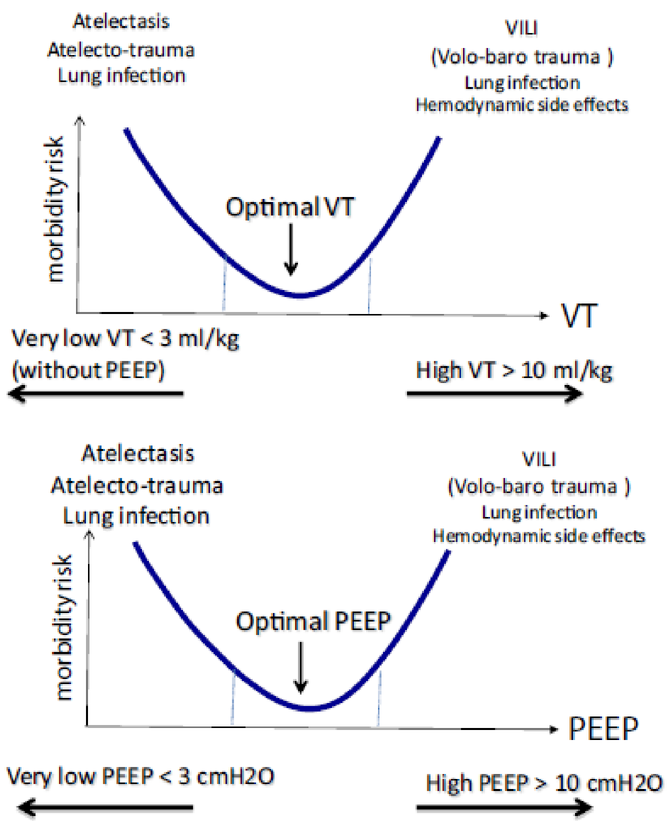
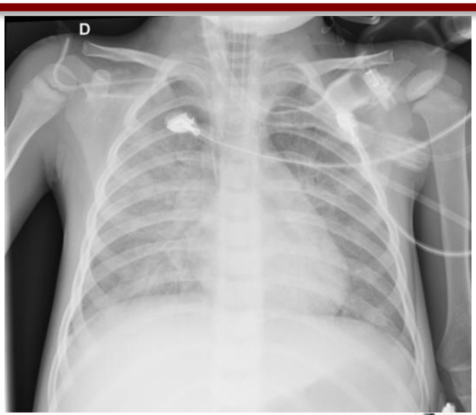
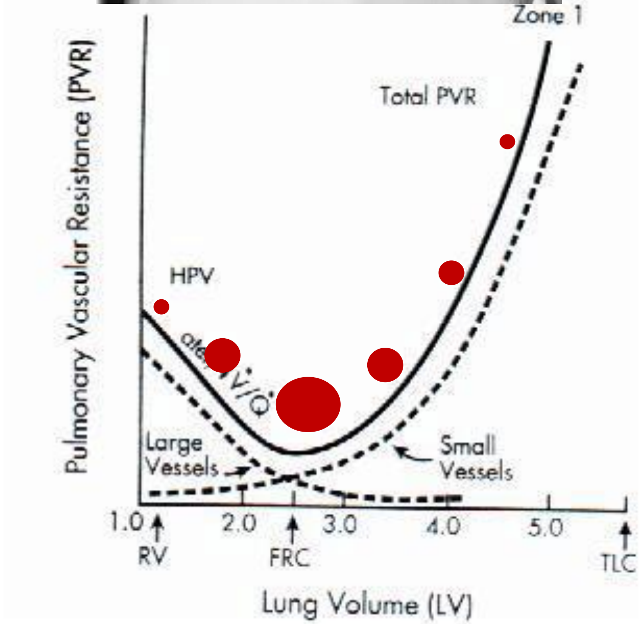


Fig. 1 Optimal tidal volume and PEEP level ranges and its related complications in patients with healthy non-ARDS lungs. V_T tidal volume, *PEEP* positive end expiratory pressure, *VILI* ventilator-induced lung injury





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What respiratory targets should be recommended in patients with brain injury and respiratory failure?

Intensive Care Med (2019) 45:683–686

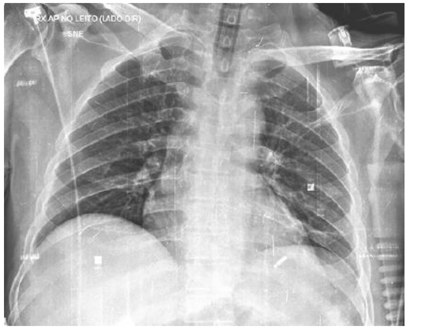
Shirin K. Frisvold[1], Chiara Robba[2] and Claude Guérin[3,4,5,6,7*]

Ventilatory strategies	VT	PEEP	RM	Prone Position	ECMO	Ventilatory Targets
ABI	• Low evidence • VT 6-9 ml/kg PBW • Pplat<30 cmH_2O	• Low evidence • Could impair venous return • Hyperinflation can cause hypercapnia	• No evidence • Might increase ICP	• No evidence • Might increase ICP	• No evidence	• PaO_2>75 mmHg • Normocapnia • $PaCO_2$<30 mmHg not recommended
ARDS	• Strong reccomendation • VT 6-ml/kg PBW • Pplat<30 cmH_2O	• FIO2/PEEP table ARDS network	• Conditional recommendation	• Strong recommendation if severe	• Might be used as rescue therapy	• PaO_2 55-80 mmHg • Any $PaCO_2$ if pH>7.25
Final Recommendation ABI+ARDS	• Protective VT • Individualize VT according to PL and DP • Increase RR to prevent hypercapnia	• Individualize PEEP based on cerebral and lung compliance • Avoid hyperinflation	• Only on a case-by-case basis and guided by neuromonitoring	• Could be considered • Use neuromonitoring	• Only in specific cases as rescue therapy when conventional treatment fails • Consider heparin dose	• PaO_2>75 mmHg • Protective ventilation • Normocapnia or based on neuromonitoring and pH

Optimization of conditions for apnea testing in a hypoxemic brain dead patient

Carneiro B et al.

Rev Bras Ter Intensiva. 2019;31(1):106-110



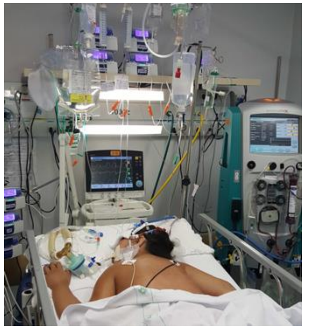


Table 1 - Blood gas and evolution of respiratory mechanics for initiation of the apnea test

Variable	Protective VM	Protective MV + Prone	Protective MV + Prone + high PEEP	Protective MV + Prone + high PEEP + TV 8mL/kg	Posttest
Time	10:38 a.m.	1:59 p.m.	3:24 a.m.	4:21 p.m.	5:39 p.m.
Blood gas parameters					
pH	7.3	7.29	7.24	7.26	6,97
PaO_2	109	68.4	165	241	243
$PaCO_2$	40.7	39.3	42.2	41.3	93.7
Bicarbonate	19.5	18.5	17.8	17.9	20.6
SBE	- 6	- 6.8	- 8.4	- 8.2	- 14.2
$SatO_2$	97.2	93.9	99.1	85.8	98.5
Ventilatory parameters					
PEEP	5	8	15	15	10
FiO_2	1	0.4	1	1	1
PaO_2/FiO_2 ratio	109	171	165	241	-
Respiratory rate	22	22	22	22	-
TV	370	370	370	480	-
Plateau pressure	20	20	25	30	-
ΔP	15	12	10	15	-

MV - mechanical ventilation; PEEP - positive end-expiratory pressure; TV - tidal volume; PaO_2 - partial pressure of oxygen; $PaCO_2$ - partial pressure of carbon dioxide; SBE - standard base excess; $SatO_2$ - oxygen saturation; FiO_2 - fraction of inspired oxygen; ΔP - lung-distending pressure.

Proposed safe apnea test using positive end-expiratory pressure valve and short-term blood gas analysis

Medicine (2019) 98:19(e15602)

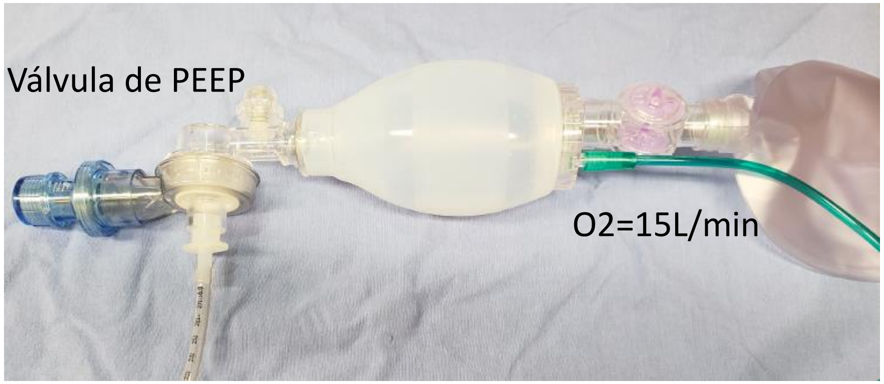
Observational study

Jin Park, MD[a], Young-Joo Lee, MD, PhD[b], Kyung Sook Hong, MD, PhD[c,*]

Table 1

Demographic and clinical characteristics.

	CAT* group (n=49)	MAT† group (n=77)	P value
Sex (male:female)	35:14	43:34	.092
Age (yr)	46.1±12.5	49.8±13.7	.715
≤60	45 (91.8%)	61 (79.2%)	.080
>60	4 (8.2%)	16 (20.8%)	
BMI‡ (kg/m²)	23.4±4.3	23.2±3.3	.131
<23	24 (49.0%)	35 (46.7%)	.855
≥23	25 (51.0%)	40 (53.3%)	
Hopitalization (days)			
Previous cardiologic disease history	4 (8.3%)	4 (5.2%)	.482
Previous pulmonary disease history	2 (4.2%)	2 (2.7%)	.643
Cause of brain death			.115
Sudden cardiac arrest	6 (12.2%)	18 (23.4%)	
Spontaneous cerebrovascular hemorrhage	14 (28.6%)	31 (40.3%)	
Traumatic brain injury	9 (18.4%)	8 (10.4%)	
Other neurologic diseases	4 (8.2%)	4 (5.2%)	
Hanging-induced hypoxic brain injury	14 (28.6%)	16 (20.8%)	
Near-drawn-induced hypoxic injury	2 (4.1%)	0	



MAT group
(Modified)

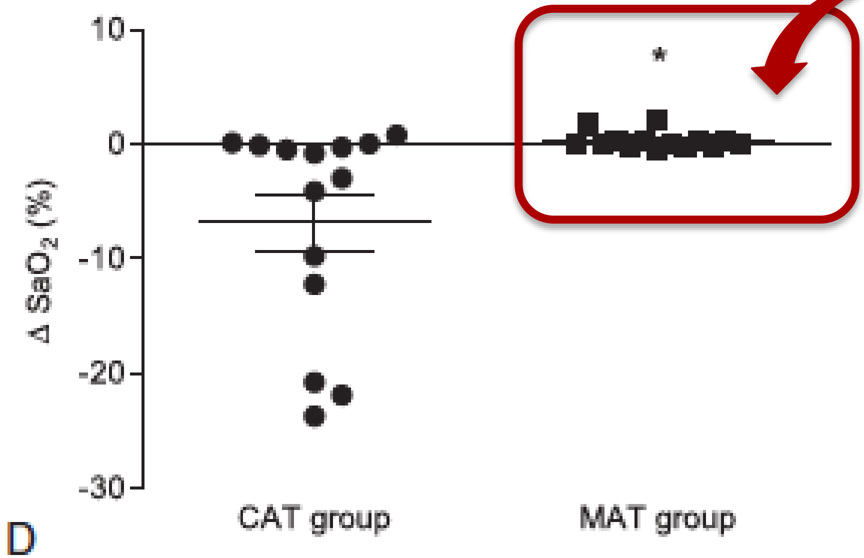
CAT group
(Conventional)

Proposed safe apnea test using positive end-expiratory pressure valve and short-term blood gas analysis

Medicine (2019) 98:19(e15602)

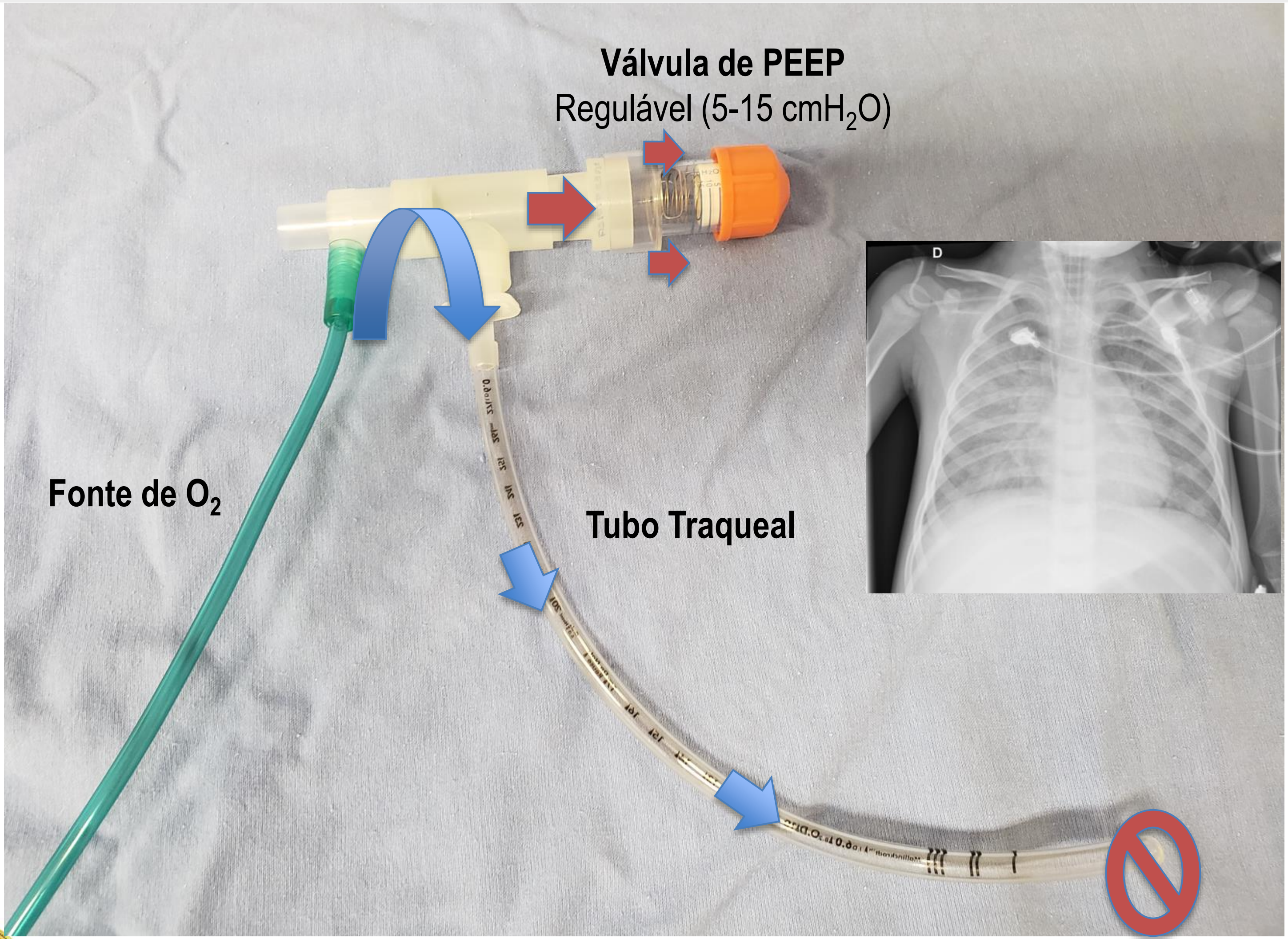
Observational study

Jin Park, MD[a], Young-Joo Lee, MD, PhD[b], Kyung Sook Hong, MD, PhD[c,*]



Post-apnea test PaO2 was higher in the Modified group than in the Conventional group (151.4±131.1 mmHg in CAT group vs 300.6±143.7 mmHg in MAT group, P<.05).

Tubo “T de Ayre” acoplado com válvula de PEEP



Teste de apneia em ME: situações não usuais

A Brain Death Dilemma: Apnea Testing While on High-Frequency Oscillatory Ventilation

Natalie Gillson, MD[a], Pedro Weisleder, MD, PhD[a,b], Margie A. Ream, MD, PhD[a]

Pediatrics 2015;135;e5

Confirmation of brain death on VA-ECMO should mandate simultaneous distal arterial and post-oxygenator blood gas sampling

Joshua Ihle[1,2,3*] and Aidan Burrell[1,3,4]

Intensive Care Medicine 2019

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Obrigado pela atenção!!

Imagem autorizada – UTIP/HCPA 03/2019

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